ACTIVITIES INDUCED IN MAGNESIUM, TANTALUM, AND COPPER BY X-RAYS FROM THE 20 MEV BETATRON

BY

JOHN McELHINNEY

B. S., Ursinus College, 1942

M. S., University of Illinois, 1943

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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ACTIVITIES INDUCED IN MAGNESIUM, TANTALUM, AND COPPER BY THE X-RAYS FROM THE 20 MEV BETATRON

The gamma-induced nuclear reactions in magnesium, tantalum, and copper were studied by means of the radioactivity of the resulting nuclei. Excitation functions were obtained by plotting counts/minute per R/minute of x-radiation as a function of betatron energy. Thresholds, which are equal to the binding energies of the ejected particles in the original nucleus, were estimated.

In the following table are listed the measured thresholds of the reactions studied:

Reaction	Half-Life	Observed Threshold (MEV)	Specific Activity 5 MEV Above Threshold
$Mg^{24}(\gamma,n)Mg^{23}$	11.6 Sec.	16.4 ± 0.3[1]	2.3×10^{-19}
$Mg^{25}(\gamma,p)Na^{24}$	14.8 Hr.	13.2 ± 0.5	1.4×10^{-19}
$Mg^{26}(\gamma,p)Na^{25}$	62 Sec.	15.6 ± 0.5	0.9×10^{-19}
$Cu^{63}(\gamma,n)Cu^{62}$	10.5 Min.	10.9 ± 0.3[2]	11×10^{-19}
$Cu^{65}(\gamma,n)Cu^{64}$	12.8 Hr.	10.2 ± 0.4	22×10^{-19}
$Ta^{181}(\gamma,n)Ta^{180}$	8.2 Hr.	7.8 ± 0.3	39×10^{-19}

Specific activity referred to in the table equals the counts/minute per R/minute per atom of the isotope in question, at the end of a saturated irradiation, if all activity were counted.

The observed thresholds of the two (γ,p) reactions must be considered only as upper limits due to the small penetrability of the low energy protons through the Coulomb barrier. However, the listed $Mg^{26}(\gamma,p)Na^{25}$ threshold is expected to be closer to its true value than the $Mg^{25}(\gamma,p)Na^{42}$ measure-

ment due to a greater sensitivity of detection in the former case.

Threshold energies were measured with respect to the $Cu^{63}(\gamma,n)Cu^{62}$ threshold which was assumed to be 10.9 ± 0.3 MEV.[2] An independent calibration gave the same value within experimental error. Errors in the measured thresholds are due to uncertainties in the calibration plus uncertainties in the observed zero intercept because of counter background and radioactivity from other reactions.

It was shown that the sodium activities resulted from (γ,p) reactions and not (n,p) reactions. Na^{25} was identified chemically. The energies of the betas from Na^{25} and of the positrons from Mg^{23} were measured by means of aluminum absorbers and the maximum energies were found to be 3.4 ± 0.2 MEV and 3.0 ± 0.2 MEV respectively.

All the excitation functions were shown to be similar in shape if the thresholds were put in coincidence, except those of $Mg^{24}(\gamma,n)Mg^{23}$ and $Mg^{25}(\gamma,p)Na^{24}$ which appeared to increase more rapidly with energy. A maximum was observed in the tantalum excitation function at about 18 MEV. The energy dependence of the cross section was calculated from the observed tantalum excitation function, an assumed simplified x-ray spectrum, and a calculated R-meter response. The cross section was found to rise approximately as $(E\text{-}E_t)^2$ above the threshold energy (E_t) and apparently decreased above 18 MEV. Existing theories can not give detailed cross sections, due to a lack of knowledge of the excited nuclear levels. However, they do predict a maximum in the energy region where the level width is of the order of magnitude of the level spacing.

1. R. A. Becker, A. O. Hanson, and B. C. Diven, Phys. Rev. **71**, 466 (1947).

2. G. C. Baldwin and H. W. Koch, Phys. Rev. **67**, 1 (1945).

VITA

John McElhinney was born March 25, 1921, in Philadelphia, Pennsylvania. He attended elementary, junior high, and and high schools in Germantown, Philadelphia. He attended Ursinus College, Collegeville, Pennsylvania, under one of six competitive open scholarships awarded each year, and was graduated in May, 1942, receiving the Bachelor of Science degree, "magna cum laude," with department honors in mathematics. During the summer of 1942 he completed the full-time course in Ultra High Frequency Techniques given under the ESMDT program at the University of Pennsylvania, Philadelphia. From September, 1942, until the present time he has been a graduate student at the University of Illinois, where he held a teaching assistantship from September, 1942, until April, 1944, a research assistantship from April, 1944, until November, 1945, and a National Research Council predoctoral fellowship from November, 1945, until June, 1947. During the period from October, 1944, until September, 1945, he did nuclear research at the University of Illinois under a subcontract with the University of Chicago, Manhattan District. He received the Master of Science degree from the University of Illinois in October, 1943. He is affiliated with Sigma Xi, Phi Kappa Phi, and the American Physical Society.

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